# SHOT HOLE LOGS
# AND
# GROUND ICE

## Shot Hole Logs and Ground Ice*

The shot hole driller's log is at present the best source of data for the distributional study of ground ice in the arctic. Up to now, the only practical way to obtain information on ground ice has been to examine naturally occurring sections such as those exposed along coastal bluffs. Now, however, an accurate driller's log which shows not only the footage and kind of material but, in addition, the ice, when it occurs, can be most valuable, especially if samples are collected. The amount, depth, type, and distribution of ground ice is important for many practical reasons. For example, if there is abundant ice 8 feet below the surface, this ice must not be allowed to melt either during or after the construction of roads, airfields, and towns. If the ice is at a greater depth, for example 30 feet, it could be thawed by a buried hot pipeline or an artificial reservoir created by a dam. If the ice is at a depth of 100 feet, the question arises - how did it get there? No one knows, for sure, but data from driller's logs can help to answer this puzzler.

## Types of Ground Ice

There are many different types of ground ice. The most important types, which may be encountered in shot hole drilling, are discussed below.

1. Cement (pore) ice: here ice acts as a cement to bond the individual soil grains together just as grains of sand are cemented together to form a sandstone. Cement ice is typical of sands and gravels. When frozen sand is examined, very little "ice" will be visible to the unaided eye. If a sample of frozen sand is placed in a drinking glass and allowed to thaw, the sand will usually be wet (saturated), but there will be little to no excess water on top of the sand. For this reason, sandy and coarse grained soils are generally resistant to temperature disturbances and are therefore used in road and airfield construction.

2. Segregated ice: when fine grained frozen soils, such as silty clays and clays are examined, small veins, stringers, and pellets of ice are often visible. Of particular interest are the icy soils where the amount of ice (water) far exceeds the original amount of pore space in the soil. If such a sample is allowed to thaw in a drinking glass, there will be excess water on top of the thawed soil at the bottom of the glass. Excess water above the soil is always a sign of segregated ice. Such icy soils, if thawed, can lead to serious settlement of buildings and extensive road damage.

In the western arctic, the segregated ice is not confined to the upper few feet of the ground, but occurs to depths in excess of 100 feet. Just how this segregated ice formed is uncertain. However, it is known that the excess water, which now forms the segregated ice, was "drawn" into the soil to nourish ice growth, somewhat like kerosene moves up a lamp wick to feed a flame.

Figure 1 shows a natural exposure of segregated ice near Stanton, N.W.T. The bluff is about 20 feet high. From 0 to 10 feet, the material is clay with boulders (a glacial till). The lower half of the bluff shows banded segregated ice. Chips of the banded material brought to the surface

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in shot hole drilling would show ice to the unaided eye. The material would look like a dirty muddy ice. Thawing of the bottom 10 feet of the bluff would release about 3 feet of soil and 7 feet of excess water. Such soils are said to be supersaturated, because of the excess water.

Figure 2. This coastal exposure is just southwest of Tuktoyaktuk. The bluff is about 40 feet high. Thawing of the lower 20 feet of white icy soils would yield about 1 foot of soil and about 19 feet of water. Such material would be referred to as ice in a driller's log.

Figure 3. The closeup of segregated ice from Kendall Island, N.W.T. shows nearly pure ice with a one inch dirt band. Drilling would indicate ice.

3. Ice-wedge ice: in most of the western arctic, except for areas of bedrock and very coarse gravels, ice-wedges grow during the winter-spring months to delineate tundra polygons (Fig. 4). Tundra polygons show up clearly on flats and around lakes, but are hard to recognize on many slopes and in wooded areas. Tundra polygons resemble gigantic mud cracks. In the winter (January to March), after a cold spell, the ground will contract and often tension cracks will open. The spacings of the major crack systems are from about 20 to 75 feet apart. The cracks, at the ground surface, may be as much as half an inch wide, but the crack width narrows rapidly with depth. When the snow melts in the spring, water trickles downwards and freezes in the open crack which penetrates into permafrost. Thus, the cracks become ice veins which eventually become ice-wedges.

Figure 5 shows a large ice-wedge 13 feet across and 20 feet deep, on Garry Island, N.W.T. This ice-wedge is probably over 5,000 years old. The pure ice occasionally encountered very near the surface in drilling may be wedge-ice. Typically, there may be 2 to 5 feet of peat over 5 to 10 feet of pure ice.

Thawing of ice-wedges beneath the fill of a gravel road often leads to corduroy roads, if the sand or gravel fill is too thin to prevent thawing.

4. Pingo ice: pingos are ice-cored hills which are very abundant in the area east of the Mackenzie Delta. Figure 6 shows the ice core of a 20 foot high pingo. Most pingos are found in old lake basins; their growth is associated with downward freezing which accompanies lake draining. Few seismic lines would ever be run across a prominent pingo, but some lines may cross gentle pingo swells in old lake basins. If ice is encountered from about 5 to 50 feet below the surface in an old lake basin, it may be pingo ice.

## Field description of ground ice

When cuttings of frozen ground are examined, much can be learnt from a quick "eye-ball" examination. Suggestions follow:

1. No visible ice: use descriptive terms such as clay, sand, gravel. These soils typically have cement ice and yield no excess water upon thawing.

2. Visible ice which is less than 50 percent by volume: use terms icy clay, icy sand, etc. These soils look very dirty and will yield excess water upon thawing.

3. Visible ice greater than 50 percent by volume: use terms such as clayey ice, sandy ice, etc. These soils will have clear ice with dirt bands. Much excess water will be released upon thawing. (Fig. 7).

4. Nearly pure ice: use term ice, even though some dirt is present. (Figs. 2, 3, 5, 6).

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Figure 3. The [illegible]

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Figure [illegible] shows a large [illegible] feet [illegible], [illegible] [illegible]. [illegible] rate [illegible].

[illegible]

4. [illegible] [illegible] high [illegible]. [illegible] [illegible].

## Field [illegible] of [illegible]

The [illegible] of [illegible].

1. [illegible]

2. [illegible]

3. [illegible]

4. [illegible]

With increasing ice content the sequence would be, for example: clay - icy clay - clayey ice - ice.

Examples: driller's logs for Figures 1 to 6 might read:

Figure 1: 0 - 10' clay and boulders; 10 - 20' clayey ice (there is excess water).

Figure 2: 0 - 20' clay and boulders; 20 - 40' ice (although there is some dirt, most of the section is of ice).

Figure 3: an entire section of this material would be listed as "ice".

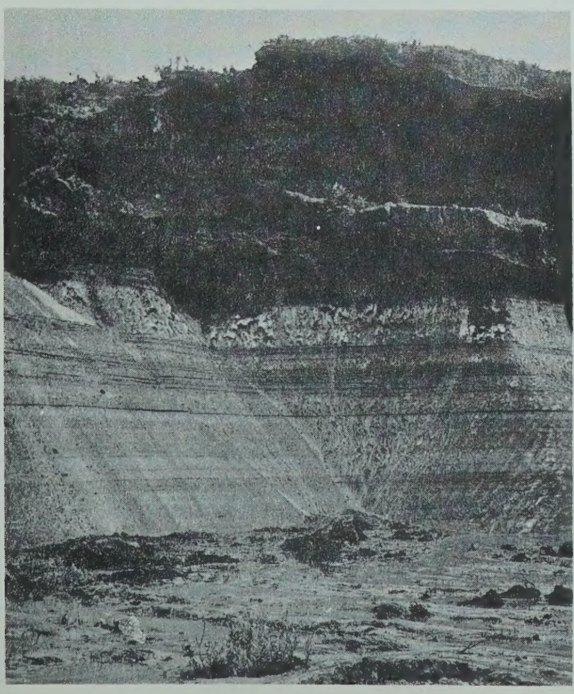
Figures 4 and 5: the depth of ice would depend upon the precise location of the shot hole.

Figure 6: 0 - 5' sand; 5 - 15' ice.

Thicknesses: it would be most helpful if the thicknesses of the different materials were given. For example, clay and boulders are usually indicative of glacial materials and their thicknesses are important. If a sandy formation is made up of layers of sand and ice, a note to that effect is helpful, even if the thicknesses of individual beds cannot be noted.

Sampling: in some instances samples of drill cuttings have been collected by drillers for subsequent water content analyses. Samples taken for moisture content should be preserved in the frozen state if collected in ordinary sample bags. During the winter this should not be difficult but in summer it is best to use sealed cans and thereby maintain the water content until measurements can be made. The information on the shot hole log is greatly enhanced when it can be combined with measurements taken on properly identified and preserved soil samples.

Miscellaneous: observation on "air" or "gas" pockets, "wet" or "dry" sands, etc. are all of value.



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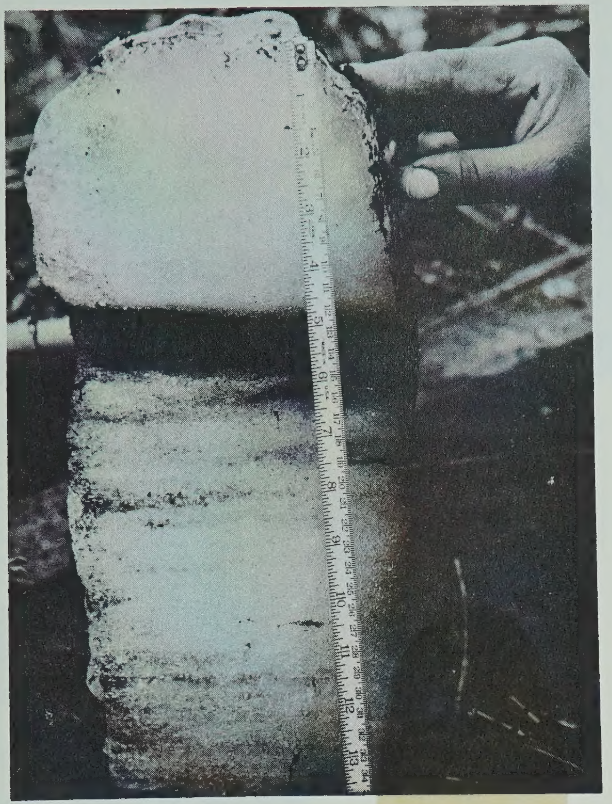

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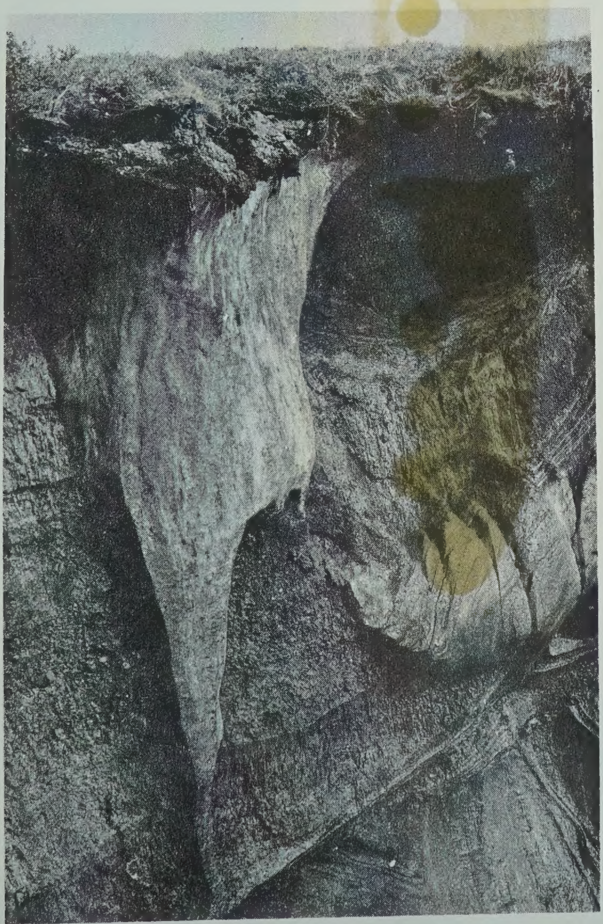

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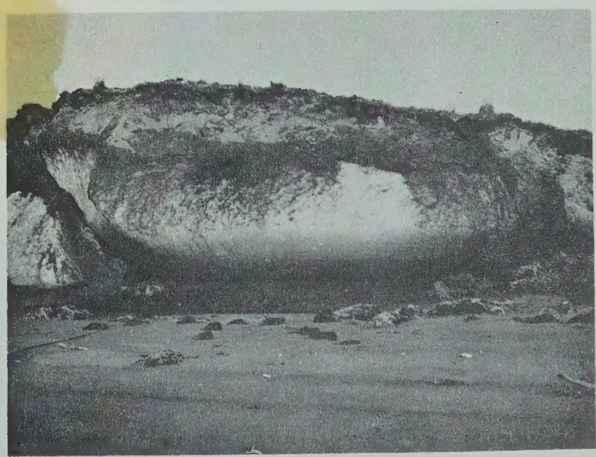

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